# ABSTRACT

Adsorption is one of the most commonly used methods in water treatment processes. It is attractive due to it easy operation and the availability of a wide variety of commercial adsorbents. Adsorbents prepared from waste materials for the treatment of dyeing effluents have high significance in environmental sustainability. The objective of the present study is to characterize quality and evaluate the efficiency of using an agricultural byproduct, cocoa (Theobroma cacao) shell activated carbon as an adsorbent for the removal of acid (AR18, AB92), basic (RhB, MG) ,direct (CR, DB GL) and reactive (RO16, RB2) dyes. The BET surface area and pore size distribution of CSAC were determined by adsorption-desorption nitrogen isotherms at the temperature of –196°C using surface area analyzer. Surface morphology, thermal stability and functional groups were examined using Scanning electron microscopy (SEM), Thermogravimetric analysis (TGA) and FTIR studies, respectively. The operation parameters investigated in batch mode process include initial dye concentration and contact time, pH of solution, adsorbent dosage and temperature.

The equilibrium adsorption isotherms have been examined by applying Langmuir, Freundlich, Temkin, Harkins-Jura and Halsey isotherm models. The adsorption of all dyes was found to follow Langmuir model. The calculated dimensionless separation factor, $R_L$, indicated that the adsorption of all dyes onto CSAC was favorable. Pseudo-first order, pseudo-second order

kinetics and Elovich model were used to analyze the kinetic data. Adsorption kinetics analyzed using the regression results showed that the adsorption kinetics was more accurately described by a pseudo-second order model for whole systems of dyes studied. To test the recoverability of the adsorbed dye molecules, desorption experiments were done with neutral pH water, sulphuric acid (1M), sodium hydroxide (1M) and 50 % acetic acid (v/v) as the desorbing agents. Desorption of all dyes studied except DB GL in acetic acid (organic medium) indicated the adsorption of dyes on CSAC was through by activated chemisorption mechanism. Desorption of DB GL by alkaline medium confirmed the physisorption mechanism.

Mass transfer studies by intraparticle and liquid film diffusion models for the adsorption process was found to be controlled by both particle and film diffusion. Analysis of adsorption data using Boyd plot confirms that film diffusion was the rate limiting step in the sorption process. The magnitude of activation energy ($E_a$) was evaluated for confirming the type of adsorption. Various thermodynamic parameters, such as Gibbs free energy change ($\Delta G^0$), enthalpy change ($\Delta H^0$) and entropy change ($\Delta S^0$), were calculated, which indicated that the present system was spontaneous and endothermic process. A single stage batch adsorber design of the adsorption of all dyes onto CSAC has been studied based on the Langmuir isotherm equation. The results indicated that CSAC could be employed as an alternative to commercial adsorbents in wastewater treatment for the removal of colour and dyes.